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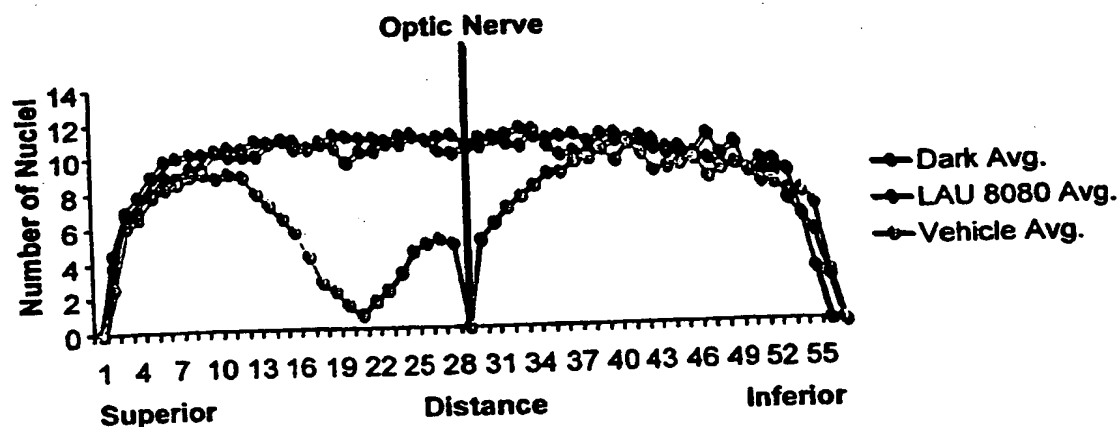
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(54) Title: SYNTHESIS AND USE OF THIENOTRIAZOLIDIAZEPINES



(57) Abstract: A new method to synthesize the platelet-activating factor antagonist which is a derivative of thienotriazolidiazepene, tetrahydro-4, 7, 8, 10 methyl-1-(chloro-2 phenyl)-6 (methoxy-4 phenyl carbamoyl)-9 pyrido[4,3-:4,5] thieno[3,2-f] triazolo-1,2,4 [4,3- $\alpha$ ] diazepine-1,4] is disclosed. The compound synthesized by this new method has been designated "LAU-8080" which has the same structure as the compound currently named in the literature as "BN-50730." LAU-8080 was shown to prevent photoreceptor cell death, inhibit pathological neovascularization in the retina, and minimize the loss of neurons due to ischemic-reperfusion damage due to stroke. Thus LAU-8080 can be used to treat the retinal diseases of age-related macular degeneration, retinitis pigmentosa, and diabetic retinopathy. It can also be used to minimize the neuronal damage due to stroke.

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## SYNTHESIS AND USE OF THIENOTRIAZOLODIAZEPINES

### TECHNICAL FIELD

This invention pertains to a new method of synthesizing a derivative of thienotriazolodiazepene [tetrahydro-4,7,8,10 methyl-1(chloro-2 phenyl)-6 (methoxy-4 phenyl-carbamoyl)-9 pyrido [4',3'-4,5] thieno [3,2-f] triazolo-1,2,4 [4,3-a] diazepine-1,4] and to new methods of using this compound therapeutically to treat age-related macular degeneration, retinitis pigmentosa, diabetic retinopathy, and stroke related neuronal damage.

### BACKGROUND ART

U.S. Patent No. 5,492,906 discloses synthesis and use of several derivatives of thieno-triazolo-diazepine, including tetrahydro-4,7,8,10 methyl-1(chloro-2 phenyl)-6 (methoxy-4 phenyl-carbamoyl)-9 pyrido [4',3'-4,5] thieno [3,2-f] triazolo-1,2,4 [4,3-a] diazepine-1,4. However, the synthesis is different from that reported below.

The derivative of thienotriazolodiazepene of interest when synthesized by the method disclosed in U.S. Patent No. 5,492,906 has been described in the literature as a platelet-activating factor antagonist and named BN-50730.

Age-related macular degeneration involves a complex pathophysiology characterized by photoreceptor cell death and in some cases also pathological neovascularization.

Retinitis Pigmentosa is an inherited form of retinal degeneration that has been linked to mutations in several genes. Blindness occurs due to the selective death of photoreceptor cells.

Diabetic retinopathy involves pathological neovascularization that leads to functional impairments in the retina and eventually to retinal detachment.

Platelet-activating factor (PAF; 1-O-alkyl-2-acetyl-sn-glycero-3-phosphocholine) is a membrane-derived second messenger that is a potent mediator of inflammatory, ischemic, and immunological responses. PAF is rapidly produced in tissues in response to injury and other forms of stimulation. See N.G. Bazan et al., "A Platelet-activating factor and retinoic acid synergistically activate the inducible prostaglandin synthase gene," *Proc.Natl.Acad.Sci.USA*, vol. 91, pp. 5252-5256 (1994). Intracellular and cell surface binding sites for PAF have been identified and distinguished by using diverse PAF antagonists that show a preference for one or more of the binding sites. See V.L. Marcheselli et al., "A Distinct platelet-activating factor binding sites in synaptic endings and intracellular membranes of rat cerebral cortex," *Journal of Biological Chemistry*, vol. 265, pp. 9140-9145 (1990). Two binding sites found were associated with microsomal intracellular membranes and a third binding site was associated with the synaptosomal membrane (the extracellular plasma membrane). One of the internal microsomal binding sites displays the highest known affinity for PAF.

Several PAF antagonists have been identified. Most of the antagonists are competitive in nature. The antagonists can be divided into three distinct groups: PAF-related compounds such as CV 3988; synthetic PAF-unrelated compounds such as WEB 2086 and SR 27417; and natural products including BN-52021. See A.L.A. Pires et al., "A Long-lasting inhibitory activity of the hetrazepinic BN-50730 on exudation and cellular alterations evoked by PAF and LPS," *Br.J.Pharmacol.*, vol. 113, pp. 994-1000 (1994). A unique PAF antagonist, BN-50730, a hetrazepine, is known to displace PAF from microsomal membranes, but not from the synaptosomal, plasma membrane. See V.L. Marcheselli and N.G. Bazan, "A Platelet-activating factor is a messenger in the electroconvulsive shock-induced transcriptional activation of c-fos and zif-268 in hippocampus," *Journal of Neuroscience Research*, vol. 37, pp. 54-61 (1994). Moreover, BN-50730 and WEB 2086, another PAF antagonist, are known to have different dissociation kinetics. See C.L. Silva et al., "A Formation of a highly stable complex between BN-50730 [tetrahydro-4,7,8,10 methyl-1(chloro-2 phenyl)-6 (methoxy-4 phenyl-

carbamoyl)-9 pyrido [4',3'-4,5] thieno [3,2-f] triazolo-1,2,4 [4,3-a] diazepine-1,4] and the platelet-activating factor receptor in rabbit platelet membranes," *Biochemical Pharmacology*, vol. 51, pp. 193-196 (1996).

### DISCLOSURE OF INVENTION

We have discovered a new method to synthesize the platelet-activating factor antagonist which is a derivative of thienotriazolodiazepene, tetrahydro-4,7,8,10 methyl-1(chloro-2 phenyl)-6 (methoxy-4 phenyl carbamoyl)-9 pyrido[4',3'-4,5] thieno[3,2-f] triazolo -1,2,4 [4,3- $\alpha$ ] diazepine-1,4). We have named the compound synthesized by this new method "LAU-8080" which has the same structure as the compound currently named in the literature as "BN-50730." LAU-8080 was shown to prevent photoreceptor cell death, inhibit pathological neovascularization in the eye, and minimize the loss of neurons due to ischemic-reperfusion damage due to stroke. Thus LAU-8080 can be used to treat the retinal diseases of age-related macular degeneration, retinitis pigmentosa, and diabetic retinopathy. It can also be used to minimize the neuronal damage due to stroke.

### BRIEF DESCRIPTION OF FIGURES

Figure 1 illustrates the average number of photoreceptor nuclei across the retina when exposed to only dark (Dark Avg.), to bright light and LAU-8080 (LAU-8080 Avg.), and to bright light and control vehicle (Vehicle Avg.).

Figure 2 illustrates the change in angiogenesis in a mouse cornea when implanted with a control vehicle, with platelet activating factor (PAF), and with PAF and LAU-8080 (LAU+PAF).

Figure 3 illustrates the increase in percent mouse survival after a stroke was simulated by middle cerebral artery occlusion and reperfusion, and then treated with LAU-8080 as compared to treatment with a control vehicle.

Figure 4 illustrates the decrease in neurological deficits in mice after a stroke was simulated by middle cerebral artery occlusion and reperfusion, and then treated with LAU-8080 as compared to treatment with a control vehicle.

Figure 5 illustrates the reduction in infarct volume in mice after a stroke was simulated by middle cerebral artery occlusion and reperfusion, and then treated with LAU-8080 as compared to treatment with a control vehicle.

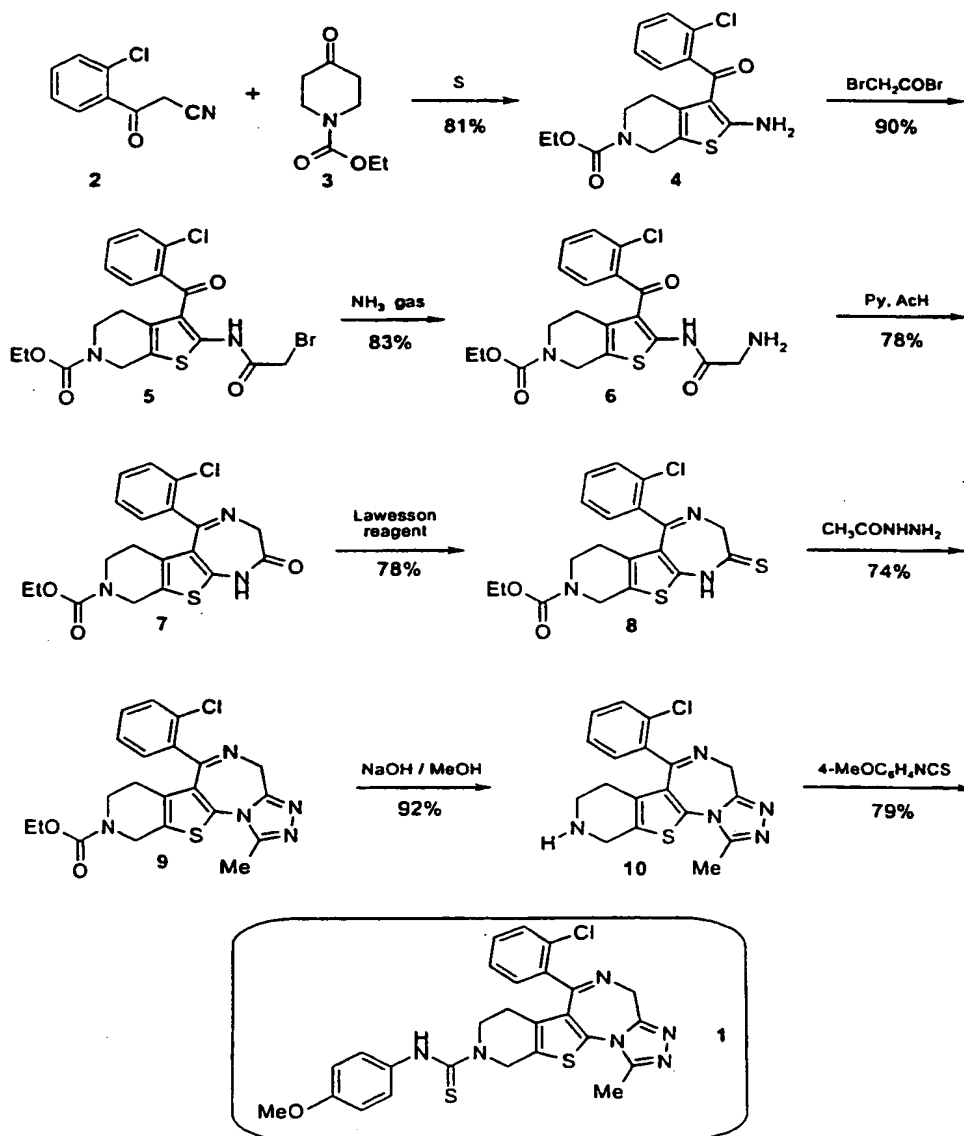
Figure 6 illustrates the increase in percent mouse survival in PAF knock-out mice after a stroke was simulated by middle cerebral artery occlusion and reperfusion, and then treated with LAU-8080 as compared to treatment with a control vehicle.

## MODES FOR CARRYING OUT THE INVENTION

### Example 1

#### *Synthesis of LAU-8080.*

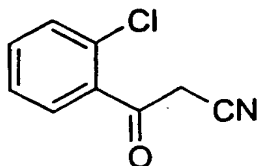
In the diagram below appears the synthetic route to obtain the target compound 1.



### Description of Synthesis Steps

All chemicals used in the synthesis are commercially available.

#### 1. Synthesis of (2-Chlorobenzoyl)acetonitrile (2)



A solution of cyanoacetic acid (5g, 0.059 mol) and 2,2'-bipyridine (2 mg, as indicator) in 300 mL of dry THF, was cooled to  $-78^{\circ}\text{C}$  with stirring, under nitrogen atmosphere. To this mixture, *n*-BuLi, 1.6 M in hexane (73 mL, 0.116 mol) was dropwise added, allowing the reaction temperature to slowly rise to  $0^{\circ}\text{C}$ .

When the red color persisted at  $0^{\circ}\text{C}$ , the slurry was recooled to  $-70^{\circ}\text{C}$  and then, (2-chloro)benzoyl chloride (5.14 g, 0.029 mol) in 50 mL of dry THF was dropwise added. The slurry was stirred at  $-70^{\circ}\text{C}$  for 1 hour, and then allowed to rise to room temperature.

Then, hydrochloric acid 1N (100 mL) was added to the mixture, which was extracted with EtOAc (3 x 75 mL), and the combined organic extracts were washed with saturated sodium hydrogen carbonate solution (2 x 75 mL) and brine (2 x 75 mL). The organic layer was then dried over sodium sulfate, filtered and evaporated under reduced pressure to give a residue which was purified by silica gel chromatography. Elution with hex/EtOAc (7:3) gave the title compound as a yellow solid (4.06 g, 77%). M.p.  $56-58^{\circ}\text{C}$  (EtOH)

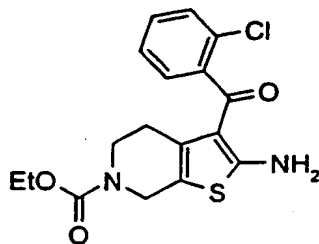
IR (KBr) : 2961, 2210, 1709, 1590, 1433, 1320, 1251,  $1053\text{ cm}^{-1}$ .

$^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  : 7.62 (d, 1H,  $J=7.8\text{ Hz}$ ), 7.50-7.39 (m, 3H), 4.14 (s, 2H) ppm.

Analysis, calculated for  $\text{C}_9\text{H}_6\text{ClNO}$  (179.61 g/mol)

	%C	%H	%N
Calculated	60.19	3.37	7.80
Found	60.63	3.53	7.63

2. *Synthesis of 2-Amino-3-(2-chlorobenzoyl)-6-ethoxycarbonyl-4,5,6,7-tetrahydropyrido[3,4-b] thiophene (4)*



A mixture of 32 g (0.178 mol) of 2-chlorobenzoylacetonitrile, 30.5 g (0.178 mol) of N-ethoxycarbonyl-4-piperidone, 6.8 g (0.21 mol) of powdered sulfur and 15.65 mL (0.178 mol) of morpholine in 190 mL of MeOH, was refluxed for 2 hours. Then, the mixture was cooled and the precipitate was filtered off and washed with diethyl ether, to yield the product as a yellow solid (43 g).

The filtrated liquids were concentrated, and the residue was chromatographed using hexane/EtOAc (8:2) as eluent, to obtain an additional crop of 12 g of 4. The total amount of the product was 55 g, (81%) as a pale yellow solid, after recrystallization from MeOH. M.p. 194-195 °C (yellow prisms, MeOH)

IR (KBr) : 3259, 2983, 1679, 1578, 1432, 1298, 1270, 1233, 1117  $\text{cm}^{-1}$ .

$^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  : 7.42-7.20 (m, 4H), 4.37 (bt., 2H,  $J=2.0$  Hz), 4.13 (q, 2H,  $J=7.1$  Hz); 3.41 (bt, 2H,  $J=5.8$  Hz), 1.80-1.74 (m, 2H), 1.25 (t, 3H,  $J=7.1$  Hz) ppm.

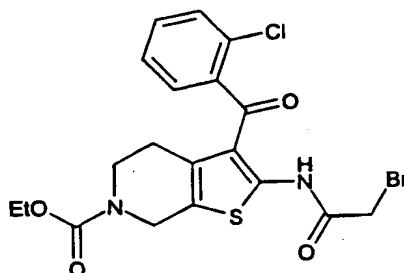
$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 50 MHz)  $\delta$  : 188.9, 174.2, 167.0, 155.3, 141.2, 130.3, 130.1, 129.7, 127.7, 126.9, 114.3, 112.9, 61.6, 42.6, 40.8, 25.9, 14.6 ppm.

Analysis Calculated for  $\text{C}_{17}\text{H}_{17}\text{ClN}_2\text{O}_3\text{S}$  (364.85 g/mol)

	%C	%H	%N
Calculated	55.96	4.70	7.68
Found	55.62	4.64	7.56



3. Synthesis of 2-Bromoacetamido-3-(2-chlorobenzoyl)-6-ethoxycarbonyl-4,5,6,7-tetrahydro pyrido[3,4-b]thiophene (5)



To a solution of 50 g (0.137 mol) of 4 in 800 mL of  $\text{CH}_2\text{Cl}_2$  at 0 °C, 30.48 g (0.15 mol, 13.25 mL) of bromoacetyl bromide were dropwise added. The reaction mixture was stirred overnight at room temperature. Then, the mixture was poured over 500 mL of ice-water and extracted with  $\text{CH}_2\text{Cl}_2$ . The combined organic extracts were dried over  $\text{Na}_2\text{SO}_4$ , and evaporated under reduced pressure.

The residue was poured into cold EtOH-Et<sub>2</sub>O and the title compound precipitated as a yellow solid, that was filtered and washed with a mixture EtOH-diethyl ether (48 g were isolated). The filtrated liquids were evaporated and the remaining oil was chromatographed in a silica gel column using  $\text{CH}_2\text{Cl}_2$  as eluent, to give an additional crop of 12 g of the product. The total amount of 5 was 60 g (90 %) as a pale yellow solid. M.p. 84-86 °C (EtOH)

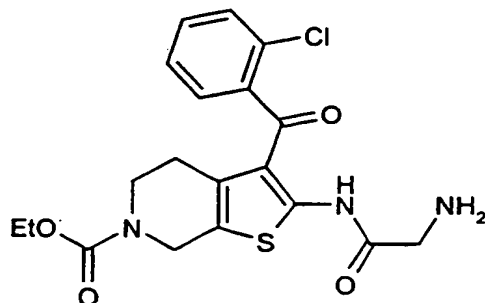
IR (KBr) : 2927, 1707, 1693, 1680, 1622, 1520, 1431, 1231  $\text{cm}^{-1}$ .

<sup>1</sup>H NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  : 12.88 (bs., 1H, NH), 7.45-7.28 (m, 4H), 4.56-4.53 (m, 2H), 4.15 (q, 2H, J=7.0 Hz), 4.13 (s, 2H), 3.46 (bt., 2H, J=5.7 Hz), 1.91-1.87 (m, 2H), 1.26 (t, 3H, J=7.0 Hz) ppm.

Analysis Calculated for  $\text{C}_{19}\text{H}_{18}\text{BrClN}_2\text{O}_4\text{S}$  (485.79 g/mol)

	%C	%H	%N
Calculated	46.98	3.73	5.77
Found	46.92	3.84	5.64

4. *Synthesis of 3-Aminoacetamido-3-(2-chlorobenzoyl)-6-ethoxycarbonyl-4,5,6,7-tetrahydropyrido[3,4-b]thiophene (6)*



To a solution of 50 g (0.103 mol) of 5 in 800 mL of dry THF, at 0 °C, NH<sub>3</sub> gas was added for 12 hours. Then, the solvent was evaporated and EtOAc (500 mL) was added. The organic layer was washed with water and brine (3 x 100 mL), dried over sodium sulphate and evaporated under reduced pressure. The crude was purified by silica gel chromatography using EtOAc as eluent, to yield the title compound 6 (36 g, 83%) as a white-yellow solid. M.p. 95-97 °C (EtOH)

IR (KBr) : 3330, 2935, 1692, 1618, 1501, 1434, 1232, 1082 cm<sup>-1</sup>.

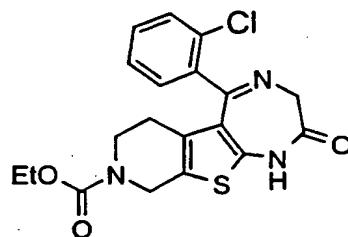
<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 13.07 (bs, 1H), 7.42-7.31 (m, 4H), 4.54-4.51 (m, 2H), 4.14 (q, 2H, J=6.9 Hz), 3.66 (s, 2H), 3.44 (bt., 2H, J=5.8 Hz), 1.90-1.87 (m, 2H), 1.25 (t, 3H, J=6.9 Hz) ppm.

<sup>13</sup>C NMR (CDCl<sub>3</sub>, 50 MHz) δ : 191.2, 178.5, 171.9, 155.3, 150.6, 140.5, 131.0, 130.2, 130.0, 127.7, 127.1, 120.3, 112.9, 61.6, 44.8, 42.6, 40.8, 25.5, 14.6 ppm.

Analysis calculated for C<sub>19</sub>H<sub>20</sub>ClN<sub>3</sub>O<sub>4</sub>S (421.91 g/mol)

	%C	%H	%N
Calculated	54.09	4.78	9.96
Found	54.38	4.91	9.22

5. *Synthesis of 5-(2-chlorophenyl)-8-ethoxycarbonyl-6,7,8,9-tetrahydro-3H-pyrido[4',3':4,5]thieno[3,2-f]-1,4-diazepine-2-one (7)*



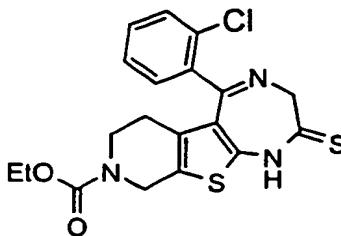
A solution of 30 g (0.071 mol) of 6 in a mixture of pyridine (93 mL), AcOH (30 mL) and toluene (560 mL) was heated under reflux with a Dean-Stark apparatus for 5 hours. Then, the solvents were evaporated under reduced pressure and the crude was chromatographed using hexane/EtOAc (1:1) as eluent to obtain 22.4 g (78%) of 7 as a white solid. m.p. 209-210 °C (CH<sub>3</sub>CN)

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 7.50-7.34 (m, 4H), 4.53 (s, 2H), 4.41-4.38 (m, 2H), 4.14 (q, 2H, J=7.2 Hz), 3.48-3.44 (m, 2H), 1.83-1.78 (m, 2H), 1.24 (t, 3H, J=7.2 Hz) ppm.  
MS (m/z, rel. int.) : 405 (8), 403 (M<sup>+</sup>, 19), 376 (36), 374 (100), 348 (9), 346 (23), 302 (9), 239 (14).

Analysis Calculated for C<sub>19</sub>H<sub>18</sub>ClN<sub>3</sub>O<sub>3</sub>S (403.89 g/mol)

	%C	%H	%N
Calculated	56.50	4.49	10.40
Found	56.23	4.55	10.17

6. *Synthesis of 5-(2-chlorophenyl)-8-ethoxycarbonyl-6,7,8,9-tetrahydro-3H-pyrido[4',3':4,5]-thieno[3,2-f]-1,4-diazepine-2-thione (8).*



To a solution of 21 g (0.052 mol) of 7 in 175 mL of dimethoxyethane at 90 °C, 12.6 g (0.031 mol) of Lawesson reagent were added. The mixture was stirred at the same temperature for 2 hours, then, it was cooled, the solvent removed under vacuum and the residue was purified by chromatography using as eluent CH<sub>2</sub>Cl<sub>2</sub> /acetone (9.5:0.5 to 9:1) to yield the title compound as a yellowish solid (18 g, 78%). M.p.236-237 °C (white yellowish powder, CH<sub>3</sub>CN)

IR (KBr) 3155, 2982, 1692, 1593, 1564, 1481, 1433, 1352, 1233 cm<sup>-1</sup>.

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 11.00 (bs., 1H), 7.42-7.32 (m, 4H), 4.80-4.76 (m, 2H), 4.54 (s, 2H), 4.15 (q, 2H, J=7.1 Hz), 3.47-3.44 (m, 2H), 1.83-1.80 (m, 2H), 1.26 (t, 3H, J=7.1 Hz) ppm

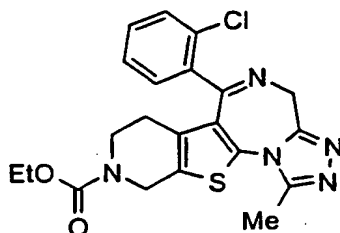
<sup>13</sup>C NMR (CDCl<sub>3</sub>, 50 MHz) δ : 196.2, 165.4, 155.3, 144.7, 137.1, 133.0, 131.2, 131.1, 130.0, 128.0, 127.1, 126.0, 64.4, 61.9, 42.6, 40.6, 25.3, 14.6 ppm.

MS (m/z, rel. int.) : 419 (M<sup>+</sup>, 29), 392 (42), 391 (22), 390 (100), 346 (15), 283 (13), 237 (5), 149 (8).

Analysis Calculated for C<sub>19</sub>H<sub>18</sub>ClN<sub>3</sub>O<sub>2</sub>S<sub>2</sub> (419.96 g/mol)

	%C	%H	%N
Calculated	54.34	4.32	10.01
Found	54.57	4.33	9.84

7. *Synthesis of 6-(2-chlorophenyl)-9-ethoxycarbonyl-1-methyl-7,8,9,10-tetrahydro-4H-pyrido-[4',3':4,5]thieno[3,2-f]-1,2,4-triazolo[4,3-a]-1,4-diazepine (9).*



A mixture of the thioamide 8 (18 g, 0.0429 mol) and acetyl hydrazine (3.81 g, 0.051 mol) in 220 mL of dioxane was heated at 130 °C for 8 hours. Then, the dioxane was evaporated, and the residue was purified by chromatography (CH<sub>2</sub>Cl<sub>2</sub> /MeOH 9.5:0.5) to obtain 9 as a yellow solid (14 g, 74%). M.p.234-235 °C (yellowish prisms, CH<sub>3</sub>CN)

IR (KBr) : 2982, 1698, 1604, 1468, 1414, 1233, 1117 cm<sup>-1</sup>.

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 7.42-7.31 (m, 4H), 5.59 (d, 1H, J=11.0 Hz), 4.85 (d, 1H, J=16.6 Hz), 4.44 (d, 1H, J=16.6 Hz), 4.22-4.19 (m, 1H), 4.14 (q, 2H, J=7.0 Hz), 3.90-3.87 (m, 1H), 3.19-3.14 (m, 1H), 2.67 (s, 3H), 2.04-2.01 (m, 1H), 1.79-1.73 (m, 1H), 1.24 (t, 3H, J=7.0 Hz) ppm.

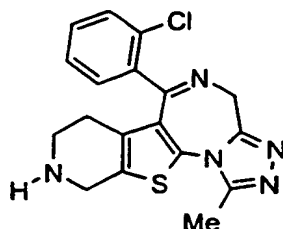
<sup>13</sup>C NMR (CDCl<sub>3</sub>, 50 MHz) δ : 164.5, 155.1, 153.5, 149.5, 137.4, 134.3, 132.5, 131.3, 131.1, 130.9, 130.1, 128.9, 127.2, 112.8, 61.8, 46.9, 42.6, 40.5, 25.3, 14.5, 11.9 ppm.

MS (m/z, rel. int.) : 443 (3), 441 (M<sup>+</sup>,10), 414 (39), 412 (100), 329 (9), 327 (21), 302 (5), 300 (15), 264 (17), 237 (19) ppm.

Analysis Calculated for C<sub>21</sub>H<sub>20</sub>ClN<sub>5</sub>O<sub>2</sub>S (441.94 g/mol)

	%C	%H	%Cl
Calculated	57.07	4.56	15.85
Found	56.96	4.61	15.63

8. <sup>12</sup>  
 Synthesis of 6-(2-chlorophenyl)-1-methyl-7,8,9,10-tetrahydro-4H-pyrido[4'3':4,5]thieno[3,2-f]-1,2,4-triazolo[4,3-a]-1,4-diazepine (10).



A solution of 9 (14 g, 0.0317 mol) in MeOH (100 mL) and 4N NaOH (90 mL) was heated at 90 °C overnight. The mixture was diluted with brine and extracted with EtOAc (3 x 100 mL). The organic phase was dried over sodium sulphate, and evaporated under reduced pressure to yield the compound 10 as a white solid (10.7 g, 92%). M.p. 196-198 °C (acetone)

IR (KBr) : 2932, 1603, 1542, 1496, 1415, 1379, 1324, 1084, 1034 cm<sup>-1</sup>.

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 7.44-7.29 (m, 4H), 5.57 (d, 1H, J=12.3 Hz), 4.19 (d, 1H, J=12.3 Hz), 4.01 (s, 2H), 3.00-2.97 (m, 1H), 2.82-2.80 (m, 1H), 2.67 (s, 3H), 2.02-1.99 (m, 1H), 1.65-1.62 (m, 1H) ppm.

<sup>13</sup>C NMR (CDCl<sub>3</sub>, 50 MHz) δ : 164.8, 153.6, 149.5, 137.7, 132.5, 131.7, 131.5, 130.9, 130.8, 129.4, 127.1, 112.8, 46.9, 44.3, 42.6, 26.3, 12.0 ppm.

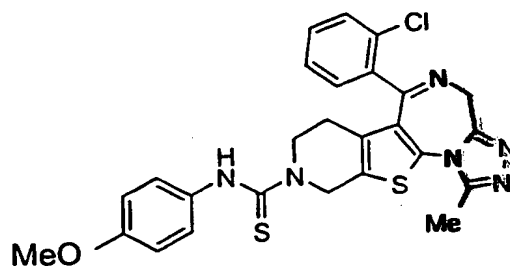
MS (m/z, rel. int.) : 371 (24), 369 (M<sup>+</sup>, 66), 340 (12), 306 (20), 305 (100), 265 (25), 264 (85), 237 (41), 235 (33), 137 (58) ppm.

Analysis Calculated for C<sub>18</sub>H<sub>16</sub>ClN<sub>5</sub>S (369.88 g/mol)

	%C	%H	%N
Calculated	58.45	4.36	18.93
Found	58.55	4.04	18.64

13

9. *Synthesis of LAU-8080 (6-(2-chlorophenyl)-9-[(4-methoxyphenyl)thiocarbamoyl]-1-methyl-7,8,9,10-tetrahydro-4H-pyrido[4',3':4,5]thieno[3,2-b]-1,2,4-triazolo[4,3-a]-1,4-diazepine (1)).*



To a suspension of 5 g (0.0135 mol) of the amine **10** in 60 mL of toluene 2.23 g (13.5 mmol) of 4-methoxyphenyl isothiocyanate were dropwise added. The mixture was stirred at room temperature for 3 hours and the white precipitate that appeared was filtered off and washed with toluene and diethyl ether. The solid was recrystallized from acetone to give 5.75 g (79%) of the title compound as a white powder. M.p.: 184-187 °C (acetone)

IR (KBr) : 3232, 1603, 1511, 1415, 1241, 1206, 1033 cm<sup>-1</sup>.

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ : 7.53 (bs, 1H, NH), 7.44-7.28 (m, 4H), 7.07 (d, 2H, J=8.8 Hz), 6.84 (d, 2H, J=8.8 Hz), 5.57 (d, 1H, J=13.3 Hz), 5.24 (d, 1H, J=15.3 Hz), 4.78 (d, 1H, J=15.3 Hz), 4.28-4.18 (m, 2H), 3.80 (s, 3H), 3.60-3.49 (m, 1H), 2.64 (s, 3H), 2.20-2.12 (m, 1H), 1.80-1.70 (m, 1H) ppm.

<sup>13</sup>C NMR (CDCl<sub>3</sub>, 50 MHz) δ : 183.9, 164.4, 157.7, 153.5, 149.6, 137.2, 134.5, 132.6, 132.4, 131.7, 131.3, 130.9, 130.2, 128.8, 128.6, 127.3, 126.5, 114.2, 55.4, 47.8, 46.8, 46.0, 25.1, 11.9 ppm.

MS (m/z, rel. int.) : 534 (M<sup>+</sup>, 0.3), 409 (6), 397 (20), 369 (100), 193 (24), 165 (88).

Analysis Calculated for C<sub>26</sub>H<sub>23</sub>ClN<sub>6</sub>OS<sub>2</sub> (535.0938 g/mol)

	%C	%H	%N
Calculated	58.36	4.33	15.71
Found	58.45	4.40	15.69

## Example 2

### *The neuroprotective effect of LAU-8080 on bright light-treated photoreceptors.*

The light-induced retina damage model selectively promotes the killing of photoreceptor cells as it occurs in age-related macular degeneration and retinitis pigmentosa.

Sprague-Dawley rats (150-175 g males) were dark adapted for 3 days. Two hours before light treatment they were injected i.p. with LAU-8080 (30 mg/kg) suspended in a vehicle (cyclo-dextrin) or just vehicle. A third group received no injection. Rats were placed in 5 inch diameter cylindrical lucite tubes which were then placed within an 8-light array of 10 inch diameter fluorescent lights (40 Watt, G.E. cool white;  $350 \mu\text{E}/\text{m}^2 \cdot \text{s}$ ; 25 klux) for up to 5 hours. After 10 days in darkness, eyes were collected and prepared for histology. One micron-thick plastic sections were examined and photoreceptor nuclei observed from the superior edge, through the optic nerve, to the inferior edge of the retina. The profile of the photoreceptor nuclear layer of the light + vehicle, light + vehicle + LAU-8080, and dark rat retinas were compared. The percent cell loss under each condition was calculated against the dark animal controls.

Normal, healthy rat retinas have a photoreceptor nuclear layer that is 12 nuclei deep. When 4 hours of light treatment occurs, 30% of the photoreceptor nuclei are lost. The majority of these are localized in the central upper half of the retina. However, while light causes severe cell loss, the same amount of light treatment has little or no effect when the animal is pretreated with LAU-8080; in an area near the center of the photodamage region, the complete lack of cell loss was noted. The photoreceptor nuclear layer remained 12 cells deep. Figure 1 is a graphic representation of these treatments. Each curve is the average of 5 animal retinas. As shown in Figure 1, light + vehicle shows the greatest cell loss (30%), while light + vehicle + LAU-8080 shows only 5% cell loss when compared to the dark retinas ( $n = 43$ ).

Four-hour constant bright light will cause about 30% of the photoreceptors to be lost after 10 days. (This is actually slightly more than 50% when considering only the upper retina). Vehicle alone has no effect on this loss of photoreceptors, but LAU-8080 almost



totally protects the photoreceptors from light damage, with a maximum cell loss of 5% across the entire retina.

LAU-8080 can be used to slow down the loss of sight in age-related macular degeneration (ARMD) and retinitis pigmentosa (RP). In these diseases photoreceptor cells die. In both ARMD and RP common photoreceptor events may lead to cell death and LAU-8080 can slow down those pathological events and therefore limit blindness.

The use of this compound will be either by injection (intramuscular) or orally in a tablet form, per os. The compound can be administered during prolonged periods of time after the disease onset is apparent.

### Example 3

#### *LAU-8080 inhibits in Vivo Angiogenesis in the Eye.*

The mouse corneal micropocket assay according to the procedure of B.M.Kenyon et al., "A model of angiogenesis in the mouse cornea," Invest. Ophthalmol. Vis. Sci. vol. 37, pp. 1625-1632 (1996), was used to test whether LAU-8080 would inhibit angiogenesis.

*Mouse corneal micropocket assay:* Corneal micropockets were created with a modified von Graefe knife in both eyes of 5-to 6-weeks old mice. Pellets containing vehicle of 0.1% BSA in PBS with 12% polyhydroxyethylmetacrylate (Hydron) were implanted in the corneas at 1mm from the limbus of the mice for a control. For the PAF experiment, 500ng cPAF was added to the pellet with vehicle. For the PAF-LAU experiment, mice were implanted with Hydron pellets containing 0.1% BSA in PBS, 500 ng cPAF, and then treated with the PAF antagonist LAU-8080 (30µg/g body weight), i.p., once a day. Six days later, corneal pictures were taken under the microscope and vessel length and clock hours of circumferential neovascularization were measured.

At 6 days, after implantation of the pellets, angiogenesis was strongly induced by PAF in mice corneas (p, 0.0001 for both vessel length and clock hours). See Figure 2. However, angiogenesis was significantly reduced in the animals treated with the PAF antagonist LAU-8080 (p<0.05).

Thus, LAU-8080 was shown to inhibit angiogenesis in the mouse cornea. LAU-8080 in either injectable (intramuscular) or in a tablet form, per os, can be used to help prevent or retard age-related macular degeneration, retinitis pigmentosa, and diabetic retinopathy. The use of this compound will be administration for prolonged periods of time

after the disease onset to slow down photoreceptor cell death and to inhibit pathological neovascularization.

#### Example 4

##### *Neuroprotection by LAU-8080 in Stroke.*

In stroke, neurons typically die due to the shortage of blood as well as to the reperfusion-induced damage. Using an animal model of stroke, LAU-8080 was injected one hour after the stroke. As described below, the use of LAU-8080 resulted in enhanced survival, improved clinical recovery, and decreased the size of the brain lesion.

To study the properties of LAU-8080 in an animal model of stroke, the technique of occluding the middle cerebral artery (middle cerebral artery occlusion, "MCAO") which has been adapted to the mouse was used. The mouse middle cerebral artery occlusion is a well-recognized model of focal stroke as neuronal damage occurs when ischemia-reperfusion damages the brain. Adult male mice (C57BL/6) weighing 22-25 grams were induced to anesthesia with 1/70/30 % halothane/nitrous oxide/oxygen, on a temperature controlled blanket. A line of PAF-R deficient mice (PAF receptor Knock-out mice), as described in S. Ishi *et al.*, "Impaired anaphylactic responses with intact sensitivity to endotoxin in mice lacking a platelet-activating factor," J. Exp. Med., vol. 187, pp. 1779-1788 (1998), was also used. The common carotid and external carotid arteries were exposed and dissected from surrounding tissue; the right external carotid artery was ligated. The right common carotid was temporarily occluded. A small arteriotomy to the external carotid artery was made so the occluding filament was introduced and advanced to the common carotid artery, and redirected into the internal carotid artery. The filament was advanced so that the blunted tip was placed in the anterior cerebral artery and the side of the filament occluded the origin of the middle cerebral artery. The common carotid artery was gently released, restoring blood flow to the carotid system. The wound was inspected for bleeding. All retracting sutures were removed, and the wound was closed. The anesthetic gases were stopped, and the animal was given oxygen until fully awake, then returned to his cage. After 60 minutes of occlusion, animals were reperfused by removal occluding filament. Animals were placed under anesthesia again, the occluding suture was

delicately withdrawn from the arterial lumen, restoring blood flow to the territory of the middle cerebral artery. The wound was closed by interrupted silk sutures. The anesthetic gases were stopped, and the animal was given oxygen until fully awake.

The treated animals received a single i.p. injection of LAU-8080 (30 mg/kg) at 1 hour after reperfusion started, and control animals received vehicle injection (2-hydroxypropyl- $\beta$ -cyclodextrin).

For purposes of measuring neurological deficits, caused by MCAO and reperfusion, animals were observed in their spontaneous movements, or induced by tail-pinching, after recovery from anesthesia and each 24 hours thereafter. Scores were collected according to Bederson's classification: a score of "0" indicates the animal moved freely changing directions. A score of "1" indicates the animal showed difficulties to extend the left forepaw. A score of "2" indicates the animal had difficulties with both left forepaw and hind paw, i.e., the animal had the tendency to run or move in circles usually to the left. A score of "3" indicates serious coordination movements, the animal after stimulation kept rolling over. Finally "4" indicates the animal could not move even after stimulation.

Volumetric changes in infarcted brain regions in mice after 1 hour MCAO and 24-48 hours reperfusion was obtained by staining brain slices 1 mm thick with 2% 2, 3, 5-triphenyltetrazolium chloride (TTC). Quantitative analysis of the volume of the infarcted area was obtained by image-analysis.

This study indicated that treatment with the specific intracellular PAF receptor antagonist LAU-8080 reduced infarct volumes in the middle cerebral artery territory, and promoted better recovery from stroke in animals after MCAO. In animals receiving 1 hour MCAO and an injection of LAU-8080 one hour after the onset of reperfusion, survival curves showed a significant increase as compared with vehicle treated animals (35% survival on LAU-8080, 8% on vehicle,  $p < 0.04$   $n = 20$  and  $22$  respectively). See Figure 3. The study was followed-up for 14 days after reperfusion started.

Neurological scores indicated a significant improvement on animals treated with LAU-8080; recovery was noticeable already 24 hours after reperfusion. See Figure 4.

Infarct volume studies on animals after 1 hour of MCAO and 48 hours reperfusion with injection of LAU-8080 at 1 hour after reperfusion onset indicated a significant reduction of the infarcted volume on the treated animals ( $p < 0.0026$ ). See Figure 5.

In the PAF receptor deficient mice (PAF receptor Knock-out mice), a small reduction in infarct volume was seen with LAU-8080. The PAF receptor Knock-out mice lack the surface receptors for PAF, but still have intracellular PAF receptors. Thus, these results confirm that LAU-8080 acts as an antagonist to the intracellular PAF receptors.

When survival studies were performed with injection of LAU-8080 one hour after reperfusion, a significant protection was obtained ( $p < 0.0074$ ) See Figure 6.

The use of LAU-8080 injection at different times during the procedure did not differ significantly from the animals treated 1 hour after reperfusion. This indicated the applicability of this drug within the time window necessary in most clinical conditions of stroke. This study demonstrates the suitability of the use of LAU-8080 as a therapeutic agent to prevent further brain damage.

Thus LAU-8080 can be used therapeutically after a stroke to minimize the loss of neurons due to the ischemia-reperfusion damage. The route of administration will be by either intramuscular or intravenous injection.

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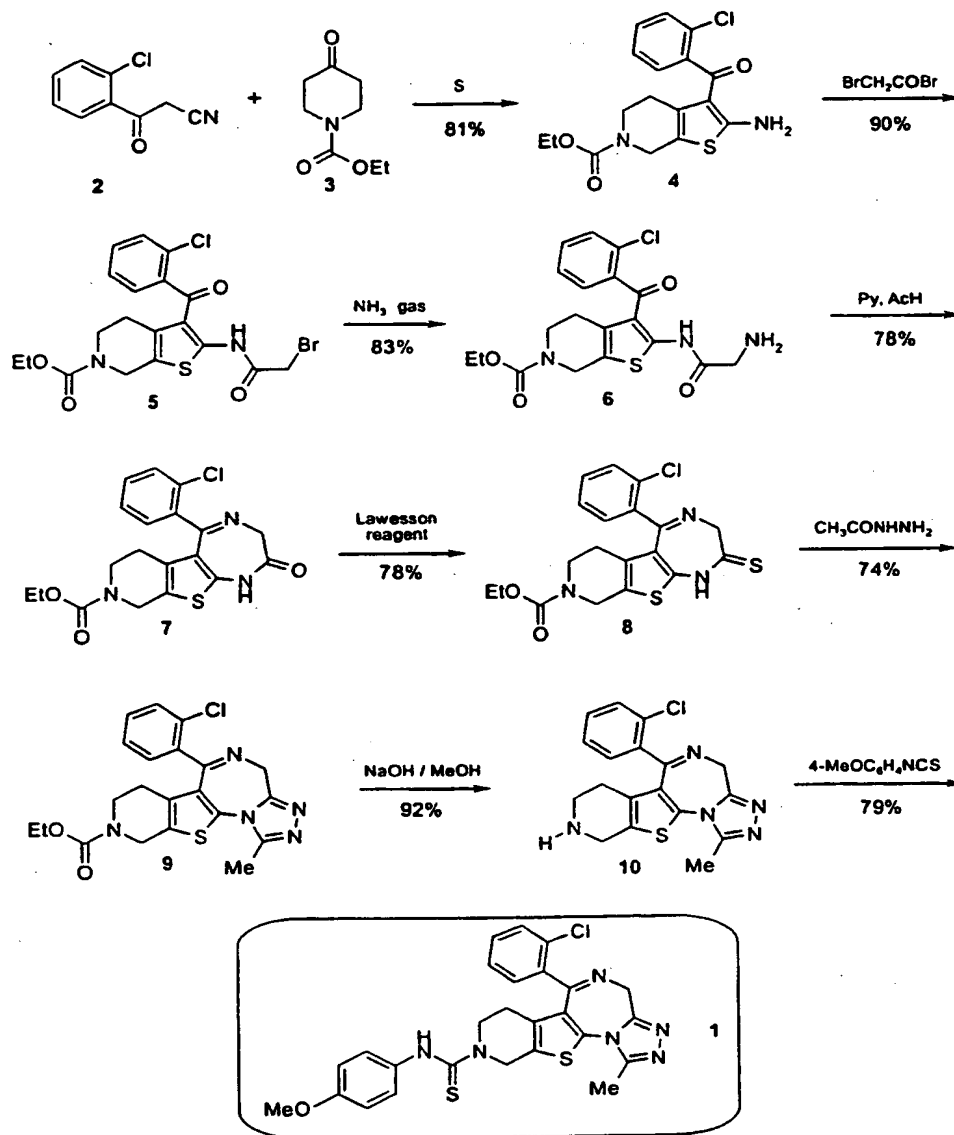
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The complete disclosures of all references cited in this specification are hereby incorporated by reference. Also incorporated by reference is E.F. Gershanik, W.C. Gordon, and N.G. Bazan, "Antagonist of the Intracellular Platelet-activating Factor (PAF) Receptor Protects Photoreceptors from Light Damage," IOVS Abstract Issue, vol. 41 (4), March 8, 2000, for presentation at the ARVO 2000 Annual Meeting, Fort Lauderdale, Florida, April 30-May 5, 2000. In the event of an otherwise irreconcilable conflict, however, the present specification shall control.

What is claimed:

1. A method to synthesis 6-(2-chlorophenyl)-9-[(4-methoxyphenyl)thiocarbamoyl]-1-methyl-7,8,9,10-tetrahydro-4H-pyrido[4',3':4,5]thieno[3,2-f]-1,2,4-triazolo[4,3-a]-1,4-diazepine, compound 1, comprising the steps of the following diagram:



2. A method of ameliorating or preventing, in a mammal, the symptoms of age-related macular degeneration in a patient, comprising administering to the mammal a therapeutically effective amount of LAU-8080.
3. A method of ameliorating or preventing, in a mammal, the symptoms of retinitis pigmentosa, comprising administering to the mammal a therapeutically effective amount of LAU-8080.
4. A method of ameliorating or preventing, in a mammal, the symptoms of diabetic retinopathy in a patient, comprising administering to the mammal a therapeutically effective amount of LAU-8080.
5. A method of ameliorating or preventing, in a mammal, the symptoms of brain damage due to a stroke, comprising administering to the mammal a therapeutically effective amount of LAU-8080.



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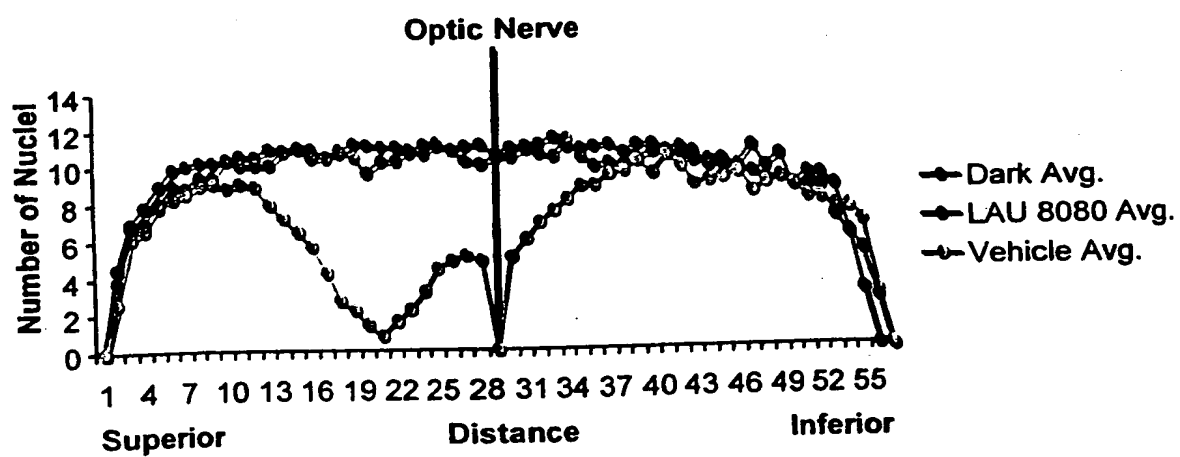


Fig. 1

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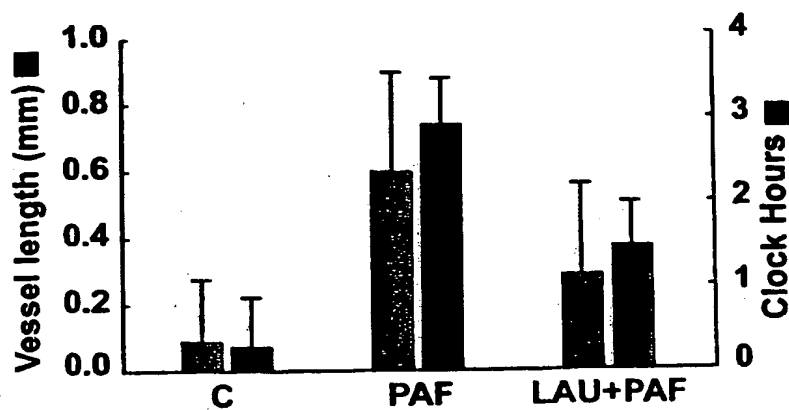


Fig. 2

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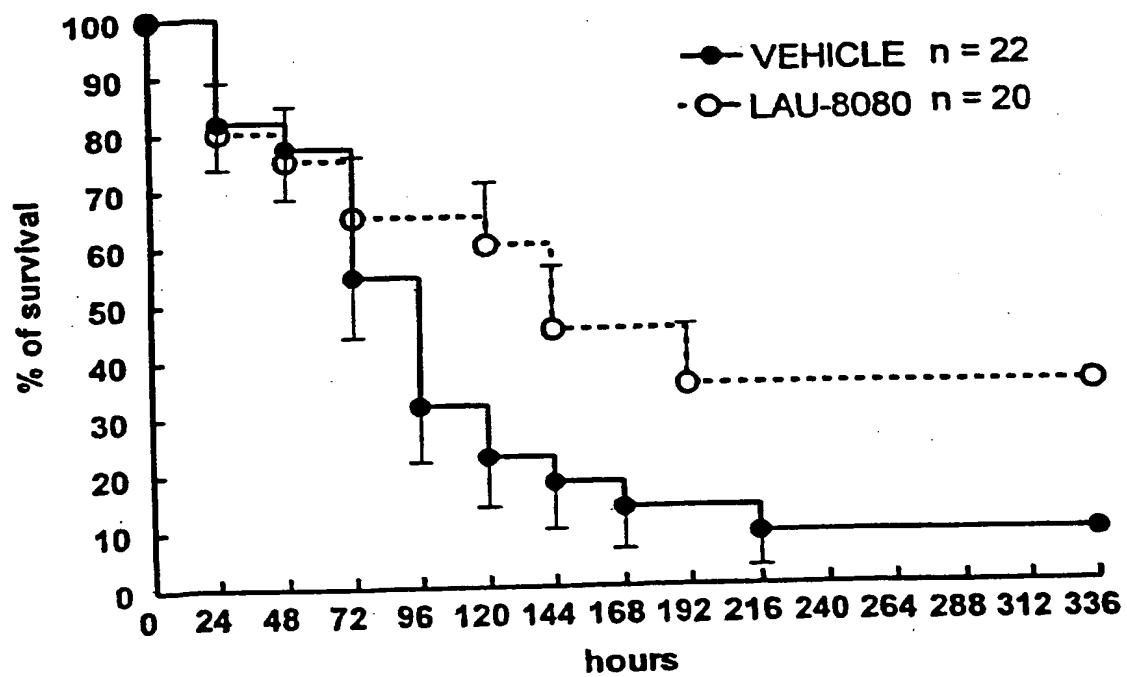


Fig. 3

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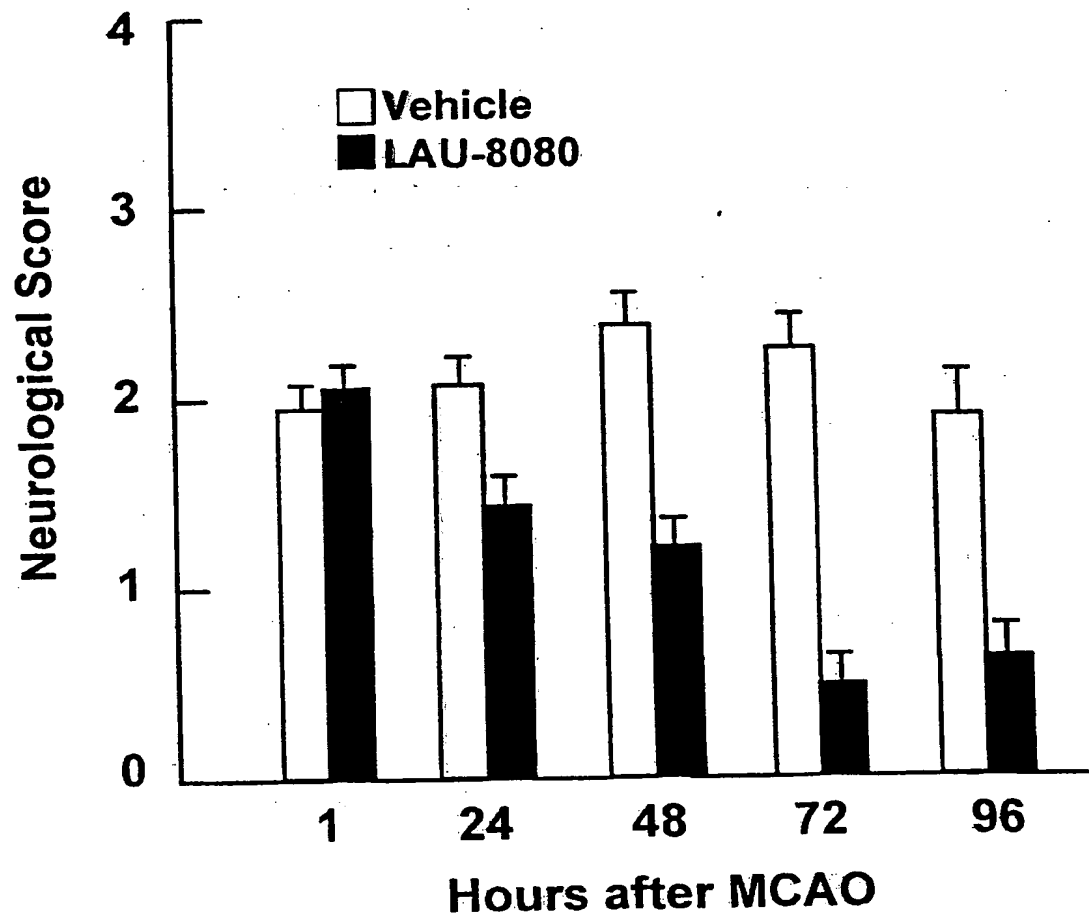


Fig. 4

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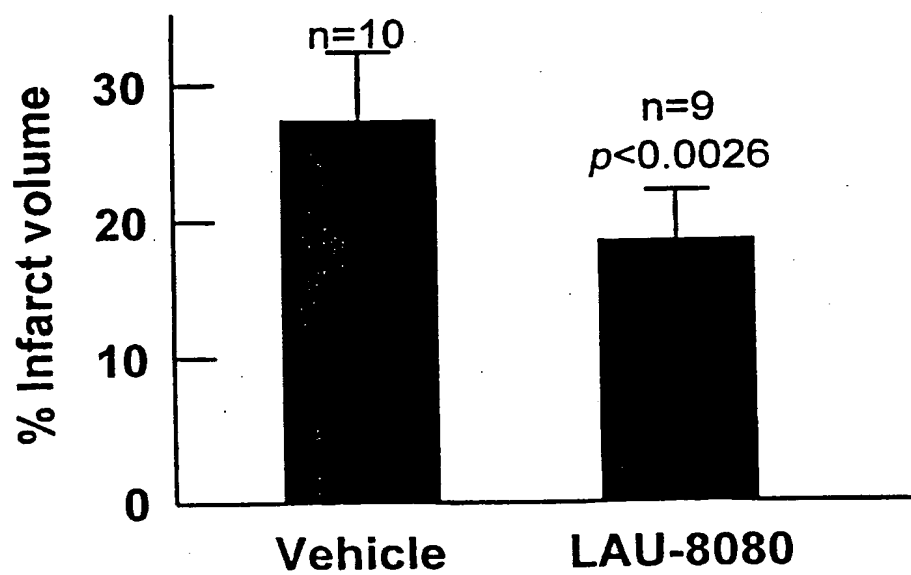


Fig. 5

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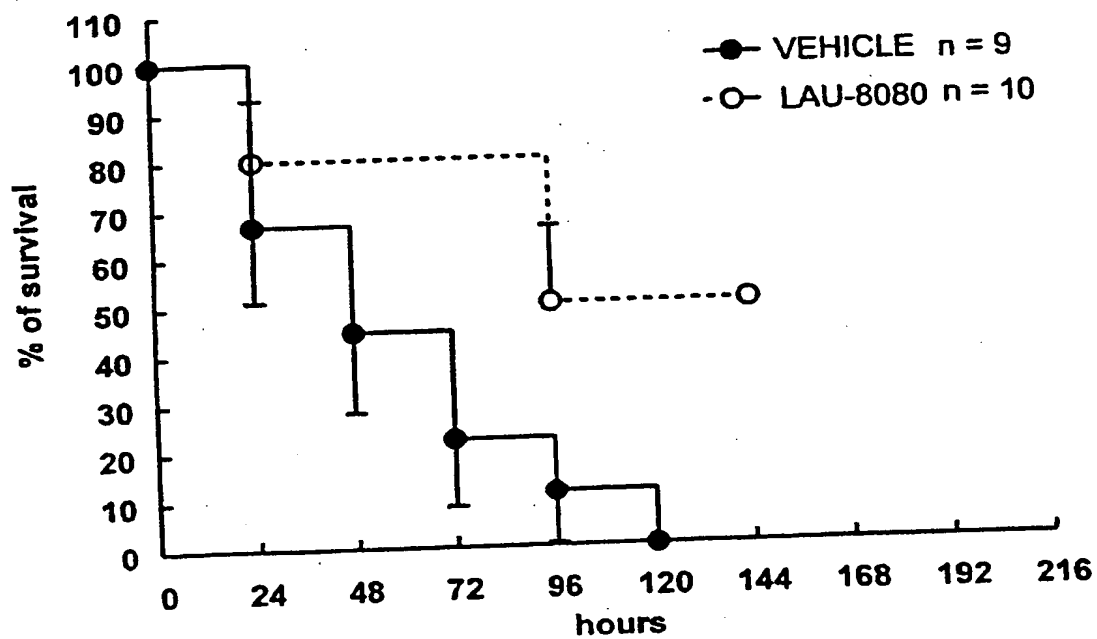


Fig. 6

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